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Jennifer M. Webb and David Frankel

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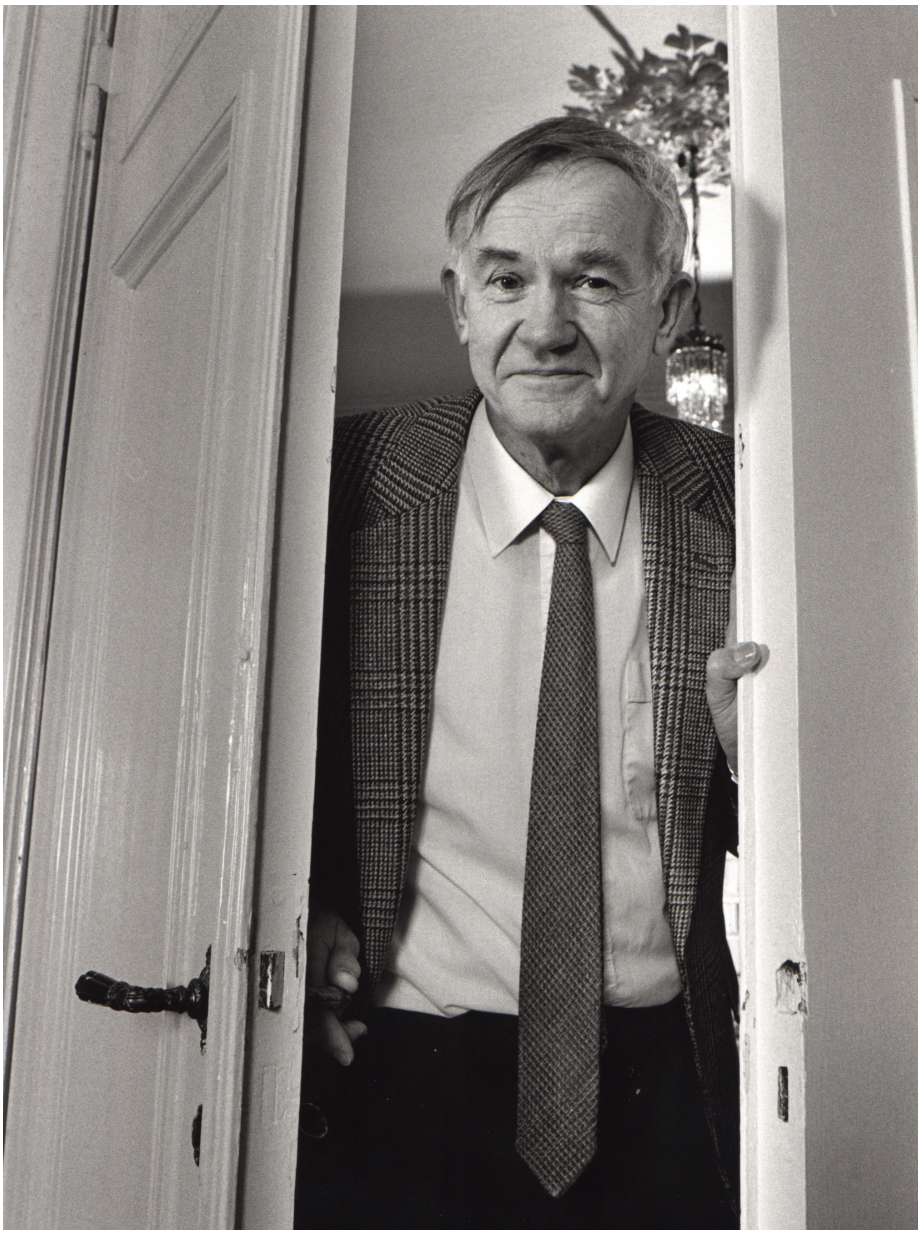

Paul Åström

This volume is dedicated to the memory of Professor Paul Åström, founder of *Studies in Mediterranean Archaeology*

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Iron Age iron: from invention to innovation

Shlomo Bunimovitz and Zvi Lederman

The introduction of iron metallurgy in the Eastern Mediterranean was considered a technological and cultural dividing line between the Bronze and Iron Ages. This idea relied on a number of presuppositions based on the belief that iron was inherently superior to and more desirable than bronze as a utilitarian and military material. Over the past four decades archaeological, philological and technological studies have amended the older assumptions and advanced new theories and questions about the introduction of iron and the cultural conditions that led to its adoption (Wertime & Muhly 1980; Waldbaum 1999).

Two major and related issues that were thoroughly revised by the new research are the alleged superiority of iron to bronze and the date of adoption of iron for 'common use'. Concerning the first issue, it is clear now that wrought iron, the form of iron produced by available early Iron Age technology, is not superior to bronze until it has been steeled and heat-treated (Muhly 2006: 21–23). As for the 'common use' of iron, according to the present state-of-the-art iron replaced bronze as leading metal only by the 10th century BCE. This important realisation owes much to Jane Waldbaum's pioneering monograph *From Bronze to Iron: The Transition from the Bronze Age to the Iron Age in the Eastern Mediterranean* which was published in 1978 in SIMA volume 54 and testifies to the significant role played by this eminent publication series in the field of Eastern Mediterranean archaeology.

In this seminal study, meticulous analysis of data collected in the late 1970s from all over the Eastern Mediterranean (Israel, Jordan, Lebanon, Syria, Cyprus, mainland Greece, Crete, the Aegean islands, Anatolia and Egypt) showed that bronze continued to reign during the 12th and 11th centuries BCE, and even in the 10th century bronze artefacts still outnumbered iron ones by a ratio of 2 to 1. Comparative examination of main categories of metal objects such as weapons and tools reiterates the picture, yet indicates that by the 10th century iron finally tipped the scales at least in the utilitarian domain. These analyses conspicuously portrayed the 'Coming of the Age of Iron' in the Eastern Mediterranean – the development of iron technology and the adoption of iron as a utilitarian metal – as a gradual and prolonged process. Moreover, they more than hinted at an underlying relationship among all areas of the Eastern Mediterranean affecting the development of iron as the primary material for the manufacture of utilitarian objects (Waldbaum 1978: 24–58, 67–73).

The original goal of Waldbaum's study was indeed to arrive at such a clearer chronological and technological definition of the 'Early Iron Age' as a single, related phenomenon in the various areas of the Eastern Mediterranean (1978: 11). Yet, by exposing the slow and late adoption of iron technology in the region it raised a major intriguing question: Why did iron replace bronze at all?

In the face of the different production technologies of bronze and iron and the fact that until the Middle Ages the manufacturing of high quality iron implements remained something of a hit-or-miss, that simple question remains the one most difficult to answer (Muhly 2006: 21). Due to the fortunes of archaeological fieldwork in the Eastern Mediterranean, the study of the transformation from bronze to iron has been based on artefacts rather than on industrial remains (Waldbaum 1978: 59–66). In consequence, the hypotheses raised to explain this literally epoch-making transformation sought explanation mainly in the economic, ecological and technological realms rather than in the social context of iron production (below). This unfortunate situation hardly changed since the publication of Waldbaum's study more than three decades ago (Veldhuijzen 2012: 237). However, the unique find of an urban early Iron Age (9th century BCE) iron smithy in our excavations at Tel Beth-Shemesh, Israel, prompted us to re-examine the innovation of iron technology and its adoption into 'common use' within their social context.

Bronze and iron: different materiality

The question why did iron replace bronze is rooted in the entirely different materiality of the two metals. Not only are their physical properties dissimilar but this dissimilarity created two utterly different

technological, organisational and symbolic worlds – the world of bronze and the world of iron (cf. Muhly 1980: 48–50; Gosden 2012: 15–18; for the notion of materiality as the mutual relations between the material world and social practices see Gosden 1994: 82–84; DeMarrais *et al*. 2004).

Since copper ores, metallic copper and copper alloys could be smelted and melted at temperatures below 1200–1150°C, working with copper and bronze meant working within the framework of casting technology. Working with iron was entirely different. Because of the high melting point of iron (1537°C), iron in the ancient Mediterranean world was never worked as a molten metal (Muhly 2006: 21). In this region the iron smelting furnace produced a spongy mass of metallic iron and slag, known as bloom. It was necessary, at temperatures of about 800–1000°C, to hammer or forge this bloom in order to drive out the spongy slag and consolidate the metallic iron. This was done at the primary smithing hearth. Yet, the processing of bloom or wrought iron into tools did not end here. Since the metal could not be cast the smith had to hammer this iron into the desired shape (secondary smithing). Intricate shapes, with delicate features, were therefore out of the question. Iron metallurgy in the ancient Mediterranean world was a metallurgy of basic shapes, of tools and implements – knives, hoes, spades, ploughshares – and weapons such as daggers, swords and arrowheads. Furthermore, these simple artefacts still needed to go through a three-step technological process – carburisation (steeling an iron object by embedding it in a charcoal fire to absorb carbon), quenching (plunging of hot steel into cold liquid), and tempering (heating of carburised iron to relieve its brittleness) – in order to transform the workable properties of iron so that it would become superior to bronze (see e.g. Maddin 1982: 303; Muhly *et al*. 1985: 68; Muhly 2006: 21–23). Thus, while iron in the Iron Age became the utilitarian metal of everyday use, bronze remained the metal for decorative and prestige artefacts. Gosden (2012: 15–18) emphasised, therefore, that iron should be perceived as repositioning bronze rather than replacing it.

The new technology involved in manufacturing iron tools and weapons, which was very different from that of bronze, brought with it a conspicuous change in the image of the smith and the concomitant symbolism related to his work. The previously unknown and somewhat frightening figure of the sweating and sooty blacksmith standing in the midst of his smithy surrounded by heat, smoke and sparks, hammering and giving shape to a piece of glowing iron triggered new imaginations. To this one should add the mysterious transformative processes performed by the blacksmith – heating, cooling in liquid and annealing – in order to achieve iron's superior hardness and strength. No wonder, then, that the introduction of regular iron production invoked the emergence of a new symbolism concerning the new metal and its manufacturers (see e.g. Eliade 1978; McNutt 1990; Snodgrass 2006: 135–136; Gosden 2012).

The difficulties and uncertainties involved in iron production and the manufacture of high-quality tools may explain the lack of any serious effort to develop iron technology during the Bronze Age (Waldbaum 1978: 17–23; 1980, 1999; Veldhuijzen 2012: 238–239). When coupled with the slow and late adoption of iron in the Iron Age, the idea that iron emerged in the Eastern Mediterranean as a utilitarian metal only as a result of some circumstantial necessity is almost inevitable. Indeed, the majority of hypotheses concerning this important process subscribed to such an idea. Yet none of them seems to stand a close scrutiny.

Why did iron replace bronze? Major hypotheses

Many scholars have wrestled with the thorny question of 'Why did iron replace bronze if in the 10th century BCE it was still technologically hardly better?' The conceived hypotheses can be categorised as 'push' theories in the spirit of 'necessity is the mother of invention' and 'pull' theories, which suggest more positive incentives for the transformation from bronze to iron. We shall briefly review some of these ideas.

For Snodgrass (1971: 230–231, 237–239; 2006), shortage of copper and tin was the main cause for the transition from bronze to iron in the Eastern Mediterranean. According to this hypothesis, the downfall of the great Late Bronze Age civilisations at the end of the second millennium was responsible for a sharp reduction in international trade and for a severe disruption in the supply of copper and especially of tin. This shortage of important yet imported ingredients of bronze forced metalworkers in the Eastern Mediterranean to turn to the more locally abundant iron.

The bronze shortage theory was originally also favoured by Waldbaum in her SIMA monograph (1978: 71–73), but later analytical research showing no diminution of tin contents in early Iron Age bronze objects made her rather sceptical about it (Waldbaum 1989: 111–117; 1999: 39). Indeed, the evidence for abundance of copper throughout the Late Bronze–Iron Age transition (Muhly 1992: 17–18) and a growing body of data accumulated in recent years that indicates the use of tin in normal quantities during this period with no attempt to replace it as hardener by other elements such as arsenic, antimony or zinc (e.g. Pickles & Peltenburg 1998; Kayafa 2006), do not support the bronze shortage theory.

Wertime (1982, 1983) proposed an alternative 'push' hypothesis for the transition from bronze to

iron. He suggested that since the production of iron is inherently more fuel efficient than bronze, iron making became more desirable by the late second millennium when serious deforestation occurred around the Mediterranean. In fact, according to Waldbaum's examination (1989), there is no evidence for a severe timber shortage in the 13th–12th centuries BCE in the metal-producing regions of the Near East. As for the claim that iron smelting was more energy-efficient than copper smelting, it seems to fly in the face of thermodynamic data (Pickles & Peltenburg 1998: 81–84).

Turning to 'pull' theories about the emergence of iron as leading metal, both Susan Sherratt (1994 and Pickles and Peltenburg (1998: 84–91) argue that the technological breakthrough of systematic carburisation (and probably also of quenching) – the consistent hardening of iron – was first achieved in Cyprus and involved iron knives. Following this achievement, so goes the argument, socio-economic circumstances on the island and in the Eastern Mediterranean during the 12th–11th centuries BCE encouraged further production of these knives and their dissemination as utilitarian tools. It is assumed that iron was regularly encountered in Cyprus as a by-product of copper smelting and refining (Sherratt 1994: 66; 2003: 44; Pickles & Peltenburg 1998: 79, 87). Notably, while Pickles and Peltenburg (1998: 84) see the wide distribution of the Cypriot steeled knives as a source for the spread of knowledge of iron as a cheap and readily available metal for various uses, Sherratt (2003: 43–44) considers them as high-value prestigious items in the face of a supposed devaluation of copper (see Muhly 2006: 20 for criticism of this view).

Muhly (2006: 28–31) also suggests that Cyprus played a crucial role in the development of iron technology already in the 11th century BCE (LC IIIB). For him, the rapid development of ironworking technology was a response to the disorder and brutality of the so-called 'dark age' and the increasing demand of the warriors or freebooters of this period for iron weapons made of carburised iron.

Currently, the idea of Cyprus as a pioneer in steel production cannot be fully supported due to the lack of iron production remains on the island (below) and the scarcity of analyses from other regions of the Eastern Mediterranean (Waldbaum 1999: 39–43; Muhly 2006: 22). As for the handful of iron knives found, for example, in Israel, they seem to represent occasional connections between the Sea People groups in Cyprus and Canaan rather than deliberate trade (Dothan 1989).

While the above concise review makes clear that the transition from bronze to iron in the Eastern Mediterranean still awaits a satisfactory explanation, Sherratt's and Pickles and Peltenburg's perception that this process should be understood in social and not only technical terms seems highly recommendable. Furthermore, it is in harmony with current anthropological and archaeological conceptions concerning technological innovations.

Innovation as a process

Recent years have seen a growing sympathy in archaeology towards the idea that technology is not just material means for production of artefacts, but rather a complex social phenomenon embedded in world-views and social strategies of specific historical contexts. Technological change is, therefore, more than just a technical-functional innovation and involves a variety of social and ideological aspects. These aspects usually exemplify that necessity alone is not the mother of invention (see e.g. Pfaffenberger 1992; Lemonnier 1993; Dobres & Hoffman 1994; Dobres 2000; Killick 2004 with additional literature; for the notion of materiality, see above). No less important is the archaeological realisation that technological innovation is not an event but a process made of a sequence of preliminary stages leading to its final implementation.

In a seminal essay on the subject of innovation, Renfrew (1978: 89) maintained that 'Innovation, the development or introduction of what is new, is evidently a process whose understanding is fundamental to the study of society and especially of change'. Indeed, archaeologists have been attempting to deal with innovation for a long time and the concept is frequently invoked to describe or explain change in material culture. However, as recently pointed out by MacDonald (2011: 106), archaeological work focusing on the notion of innovation itself is quite scarce (for some of this work see e.g. Spratt 1982; van der Leeuw & Torrence 1989; Mithen 1998; Fitzhugh 2001; O'Brien & Shennan 2010).

According to Renfrew (1978: 89), there is an important distinction between invention and innovation: 'Invention is the discovery or achievement … of a new process or form. Innovation … implies the widespread adoption of a new process or form' (cf. Torrence & van der Leeuw 1989: 3). According to this perception, innovation is dependent on the presence of local social circumstances favouring the adoption of a new process no less than on the existence of necessary knowledge or technology. Moreover, factors influencing invention and innovation differ.

Building on these ideas and elaborating Spratt's (1982, 1989) model of a complete innovation process, we would conceive of innovation as an unfolding process along the following trajectory:

1) Discovery – an addition to the body of technical knowledge.
2) Invention – the perception of the practical use of technical knowledge as product and/or technique (stages 1 and 2 can occur simultaneously).
3) Development – small scale trials of manufacture and/or use of an invention.

4) Acceptance – the social process by which an invention is adopted.
5) Implementation – the beginning of 'common use' of an invention.

Apparently, the acceptance or rejection of innovation is dependent on economic, social and cultural factors. In complex and centralised societies technological innovations are often politically manipulated. By encouraging and supporting an innovation elites create new socio-technical systems which enable them to maintain technological and organisational control (Spratt 1982: 84). As we shall see, in the case of the emergence of iron into 'common use', the stages of acceptance and implementation concur with the re-establishment of central authorities in the Eastern Mediterranean after the collapse of the old regime of the Late Bronze Age.

Early iron production in the Eastern Mediterranean: the archaeological evidence

Waldbaum lamented in her SIMA monograph that 'no direct evidence for mining, smelting, or forging of iron is yet available for the Early Iron Age' (1978: 65; see also McNutt 1990: 207). More than 30 years later, evidence for iron smelting and smithing in the Eastern Mediterranean prior to the middle of the first millennium BCE has hardly been attested (Kostoglou 2010: 174). The sparse information about alleged iron smelting at various sites in the Near East turned out to be ambiguous if not completely wrong (Veldhuijzen & Rehren 2007: 189–191 and references therein; Muhly 2006: 27). Though Cyprus was claimed to have played a leading role both in the development and the dissemination of iron metallurgy (above), no Iron Age iron smelting furnaces or iron slags have been identified as yet on the island (Kassianidou 1994, 2012, *pers. comm.*).

Secondary smithing of iron in the Near East during the Iron Age has been reported from a number of sites in Syria, Jordan and Israel. This information was critically reviewed by Veldhuijzen and Rehren (2007: 191). Apparently, most published evidence for early iron smithing dates around 700 BCE or later and mainly concerns the finding of slag without production context. Moreover, the material usually lacks proper archaeometric analysis or closer technological assessment. Evidence for secondary smithing was attested at Tel Sera^{c} (Tell esh-Shri^{c}a) in the northern Negev, Israel, where a smithy was found in the courtyard of a late 7th century BCE Assyrian citadel (Oren 1993: 1334; Rothenberg & Tylecote 1991). A concentration of metallurgical finds at Tel Ta^{c}anach in Israel (a group of iron artefacts, tuyères and by-products of the copper industry) suggested a smith's work area dating from the 10th or 9th centuries BCE (Stech-Wheeler *et al*. 1981: 248–256; Frick 2000: 148–165; Gottlieb 2010: 93; for a critique of the original dating of its context see Finkelstein 1998). However, in the absence of definitive evidence (e.g. smithing hearths) the actual nature of the remains could not be established (Stech-Wheeler *et al*. 1981: 256). A similar cache of iron implements and materials was excavated by Schumacher in a small room at Megiddo (presumably from Stratum IVA of the 9th century BCE; see Gottlieb 2010: 92 *contra* Stech-Wheeler *et al*. 1981: 256), again with no evidence for *in situ* industrial activity.

Recently, claims for finds related to secondary smithing of iron during the early Iron Age (12th–10th centuries BCE) come from the sites of Tell Ta^{c}yinat in southeast Turkey (Roams 2009) and Hazor, Israel (Yahalom-Mack *pers. comm.*). Yet no detailed archaeometallurgical information is at present available. Remains attesting to late 10th–9th century BCE bronze and iron small-scale production found in two adjacent pits have been reported from Tell es-Safi/Gath, Israel. While important for their early date, the iron working remains are quite scanty and the full context of this humble industry is unclear (Eliyahu-Behar *et al*. 2012).

In light of the disputed claims for early iron production and the paucity of tangible evidence for iron smelting and smithing in the Eastern Mediterranean prior to the late Iron Age, the importance of the recent discovery and excavation of a 9th century BCE secondary smithing workshop at Tel Beth-Shemesh, Israel (Bunimovitz & Lederman 2003: 235–237; Veldhuijzen 2009) and a contemporary smelting site at Tell Hammeh in Jordan (Veldhuijzen & van der Steen 1999; Veldhuijzen & Rehren 2007) cannot be exaggerated. Both sites were excavated and studied in parallel, with a specific metallurgical focus (Veldhuijzen 2005; Veldhuijzen & Rehren 2007). Notably, the two industrial complexes were active during the crucial years when iron became the prime utilitarian metal in the Eastern Mediterranean. The urban context of the Tel Beth-Shemesh smithy (below) prompted us to raise new ideas concerning the emergence of iron to 'common use' (Bunimovitz & Lederman 2007). These will be further elaborated below.

The iron workshop at Tel Beth-Shemesh

Tel Beth-Shemesh is a three hectare mound located in the northeastern Shephelah (lowland) of Israel, midway between Jerusalem and the Mediterranean Sea. It lies at the border zone and meeting point of three Bronze and Iron Age socio-cultural entities: Canaanites, Philistines and Israelites.

The current excavations at the site, conducted by the authors since 1990, are the third cycle of archaeological investigations of the tell. It was previously excavated in 1911–1912 by Duncan Mackenzie under the auspices

of the Palestine Exploration Fund, and in 1928–1933 by Elihu Grant from Haverford College, Pennsylvania (for a comprehensive overview of the old and current excavations see Bunimovitz & Lederman 2009).

Our excavations at Tel Beth-Shemesh have significantly refined the stratigraphy of the Iron Age levels at the tell and added much new controlled data. Following a sequence of four levels (Levels 7–4) of village-type settlements spanning the Iron Age I (ca. 1200–950 BCE), a major change in the layout of the site is discerned in Level 3 of the Iron Age IIA period (ca. 950–790 BCE). It is in this level that we first encounter the 'footprints' of state organisation, represented by public buildings spread throughout the site. The new excavations exposed a complex system of monumental fortifications, a spacious public halls-building, an impressive underground rock-cut water reservoir, and a 'commercial area'. The latter is comprised of massive foundations of a large public structure and a wide chalk-paved open area in which dozens of smashed holemouth jars, storage jars, scoops and a clay scale pan were found – all testifying to on-site economic transactions. Adjacent to our 'commercial area' Grant's excavations exposed a storehouse and a huge grain silo combined with another public building interpreted as a governmental 'residency' (Bunimovitz & Lederman 2006, 2009: 127–136) (**Fig. 1**).

The iron workshop was discovered right under the solid plaster floor of the 'commercial area' (Bunimovitz & Lederman 2003) (**Fig. 2**). Stratigraphically, it is attached to the massive public building that dominates the 'commercial area' and was established already in the early days of Level 3. C14-AMS analyses of three olive pits from the workshop resulted in a calibrated date of the 9th century BCE.

The assemblage of metallurgical debris excavated in the iron workshop at Tel Beth-Shemesh represents a secondary smithing operation as opposed to iron smelting and/or primary (bloom-) smithing. It consists of remains of hearth structures, molten and vitrified technical ceramics, charcoal and ash, square-section tuyères, a single type of slag: dozens of concave-convex 'smithing hearth bottom' (SHB) slags (**Fig. 3**), iron artefacts and fragments (e.g. billets, arrowheads, knives) and large quantities of very fine magnetic material (hammerscale – a by-product of the smithing process) (for technical description and analyses of the smithy material see Veldhuijzen 2005, 2009; Veldhuijzen & Rehren 2007: 195–199; Blakelock *et al*. 2009).

All this material, especially the large quantity of the SHB slags, indicates that smithing in the iron workshop at Beth-Shemesh was a regular operation of a considerable scale aiming at local consumption. The location of the smithy within the administrative city and amidst a group of public buildings reflects a desired closeness to the consumer (Bunimovitz & Lederman 2007; Veldhuijzen & Rehren 2007: 199;

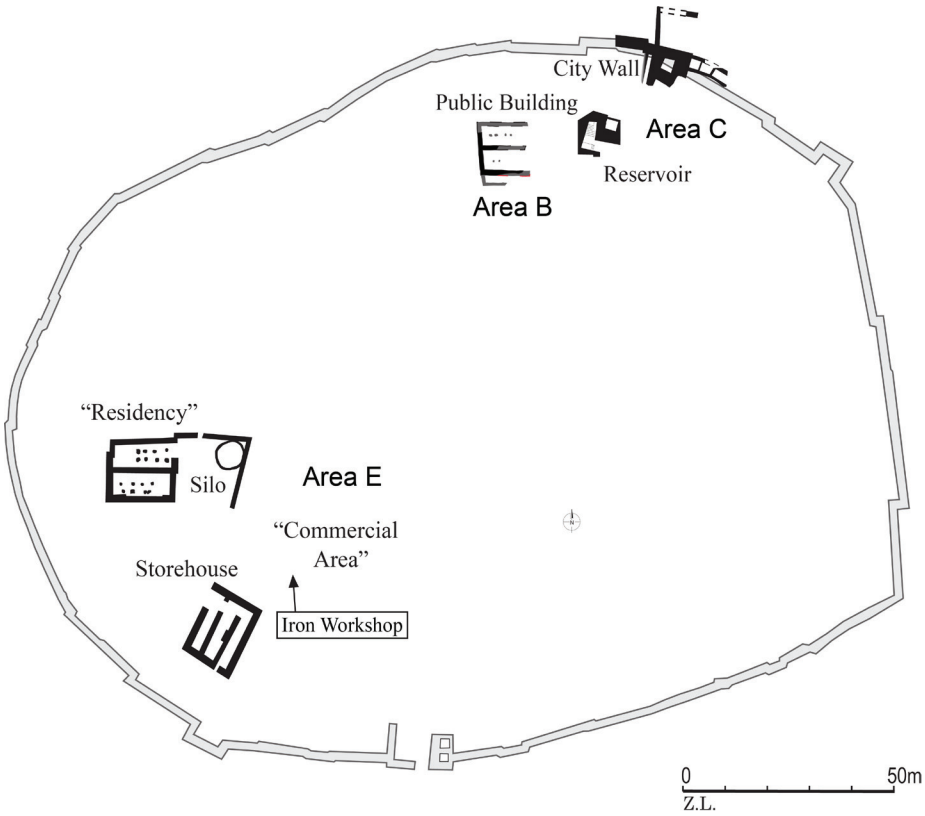

Figure 1. Integrated map showing early Iron Age II (10th–9th century BCE) public buildings revealed at Tel Beth-Shemesh by three expeditions. The iron smithy is located in the southwest quarter of the city

Figure 2. The excavation of the iron workshop at Tel Beth-Shemesh. Special techniques were used to recover and record the iron-related metallurgical activity in the smithy (Photo: H.A. Veldhuijzen)

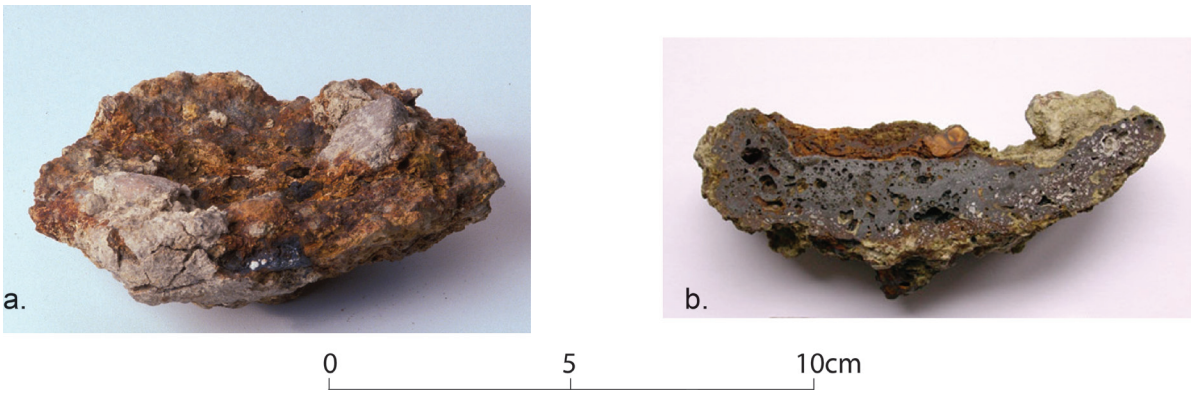

Figure 3. 'Smithing hearth bottom' (SHB) slags from the iron workshop at Tel Beth-Shemesh a. A complete SHB b. Cross-section of a SHB. Dozens of such concave-convex slags were found, attesting to regular iron secondary smithing operations in the workshop (Photos: Z. Radovan and H.A. Veldhuijzen)

Veldhuijzen 2009: 131) (**Fig. 1**). This situation provides important insights about the connection between social organisation and the emergence of regular iron production and use.

From invention to innovation: the social context of Iron Age iron

Iron was known since the fifth millennium BCE but until the Iron Age it was considered as a luxury. The humble collection of iron artefacts from this long period is comprised mainly of small pieces of jewellery. Ancient Near Eastern texts further confirm that iron was rare and invaluable. Analyses show that in the Late Bronze Age iron ores began to be smelted but iron production was not yet systematised. The use of iron artefacts was still confined primarily to ornamental, ritual and ceremonial functions rather than to military or utilitarian ones (Waldbaum 1978: 17–23; 1980: 69–82; 1999: 29–31; Muhly 2006: 24–26; Veldhuijzen 2012: 238–239, 246). This part in the history of iron usage concurs with stages 1 to 3 in our model of the innovation process. Apparently, the materiality of iron must have played a major role in the long delay of its widespread adoption, and the 'barriers to mass iron working were less technical than conceptual … Iron had to make room for itself in the practices of humans' (Gosden 2012: 15).

In the later part of the Late Bronze Age the palatial system that characterised the Eastern Mediterranean

for hundreds of years had collapsed, leaving behind a mosaic of small, localised political entities. As already noted, this major crisis had less dramatic repercussions in the field of metallurgy. Bronze continued to reign as the main metal for producing arms and tools, underlining the fact that no significant disruption in tin supply occurred. In spite of the disappearance of many important constituents of the intricate, long-range commercial and diplomatic web of tin trade, this essential component of bronze must have been acquired either directly or more probably by recycling bronze artefacts (a practice prevalent already in the Late Bronze, e.g. Karageorghis & Kassianidou 1999). Though knowledge about iron production was available already in the Late Bronze Age and the number of iron artefacts grew considerably, iron did not replace bronze. Moreover, since deliberate carburisation of iron artefacts and even quenching is attested already in Iron Age I (Muhly 2006), it becomes clear that full implementation of the innovation of iron was hindered not by lack of technological knowledge but by an absence of social and political initiative.

We turn now to stages 4 and 5 in our innovation model – acceptance and implementation – the essence of the process by which invention turns into innovation.

The revolution in the use of iron took place only in the 10th and 9th centuries BCE, with the emergence of new political entities in the Eastern Mediterranean. These entities faced a crucial choice: either to reconstruct the complex system of tin and copper trade which characterised the Late Bronze Age – an intricate and expensive diplomatic network that demanded extensive economic investment and constant maintenance by exchange of gifts, raw materials and finished goods – or to establish a much cheaper system of iron technology with available and easily accessible sources.

It can further be assumed that the new elites were quick to understand that the sociotechnic systems for iron production and manufacture are localised, hence enabling complete control over all their elements. In this light, the advantages of iron over bronze are self evident. The already known iron metallurgy was taken off the shelf and became the dominant technology. Ore sources in the vicinity, probably also known before, began to be exploited. The iron smelting site of Tell Hammeh in Jordan and the secondary smithing workshop at Tell Beth-Shemesh are conspicuous examples of this process. Close to a major iron ore deposit and active for about 100 years, from the end of the 10th to the end of the 9th century BCE, the smelting site of Hammeh may have produced between ca. 6 to 12 tons of iron metal, apparently a substantial and well-established operation as opposed to an early attempt or experimentation with new technology (Veldhuijzen 2012: 240–244, with additional bibliography). The same applies to the contemporaneous Beth-Shemesh blacksmith workshop which also attests to well-established iron technology on a considerable scale. Both sites represent, therefore, the application of an already known and practiced technology. The new finds from Tell es-Safi, also dating from the 9th century BCE, seem to point in the same direction.

Although much smaller in comparison with the vast tin and copper networks, the establishment of iron production systems still demanded initial investment. This investment could have been taken only by the new complex societies that emerged in the early Iron Age II, and undoubtedly demanded certain economic and organisational efforts. Yet it ensured involvement in the production and manufacturing process. The close spatial and contextual relations between the blacksmith workshop at Beth-Shemesh and the early Iron Age II public buildings of Level 3, as well as the fact that the lion's share of its products are arrowheads, testify to a link between the adoption of iron for 'common use' and the progress of Israelite society towards statehood (for the latter intricate issue see e.g. Finkelstein 1999, 2001; Finkelstein & Silberman 2001: 123–145; Master 2001, with additional bibliography). As will be remembered (see above), it is in this very level that the 'footprints' of a central governmental organisation were revealed – a series of building enterprises that transformed the site from a village into an administrative centre. The finds at Beth-Shemesh hint, therefore, that social and political centralisation in Judah during the late 10th and 9th centuries BCE was accompanied by appropriation and control of iron technology, presumably due to its growing economic importance.

Though the smelting operations at Tell Hammeh took place in a temporarily unoccupied site, it is clear that iron was produced there in quantities that exceed individual consumption. Moreover, the fact that the metalworkers had control over resources (mainly ore) and conducted their operations over a lengthy period of time indicates that iron smelting at Tell Hammeh was embedded in a larger socio-economic structure, although its exact nature is unclear as yet (Veldhuijzen 2012).

In this respect, the contemporary copper mining and smelting complex at Feinan, Jordan, seems to provide some relevant insights. According to Levy (2009), following the collapse of the Late Bronze 'superpowers' the nomadic population of lowland Edom formed into a local complex chiefdom that developed and controlled the flourishing copper industry in the region. A different interpretation of the chronological sequence of events postpones the peak of copper production at Feinan to the 9th century and relates it to a demand created by the new territorial states emerging in the southern Levant at that time (Finkelstein & Piasetzky 2008). Notably, both explanations relate the Iron Age copper metallurgical activity to the rise of new complex societies and this seems true also for the Iron Age iron metallurgy.

Concluding remarks

Over 30 years ago, in an important SIMA volume, Jane Waldbaum brought forth the significant issue of the late emergence of iron as a utilitarian metal. Celebrating the 50th anniversary of SIMA, it is interesting to reveal that like other 'big questions' in the archaeology of the Eastern Mediterranean no definite, consensual explanation for this question is available as yet. However, we have strived to show that the long gestation between the beginning of iron production and its full adoption to 'common use' can be explained as the outcome of social strategies rather than tecnological deficiencies. In the face of the sparse tangible evidence for Iron Age iron production we have presented new data from Tel Beth-Shemesh that indicates a close connection between the development of iron metallurgy from invention to innovation and the emergence of new Iron Age complex polities. While this process could have been a local affair in each of the sub-regions of the Eastern Mediterranean, the underlying common denominator between these seemingly isolated occurrences is socio-political evolution. In this respect it is interesting to note that Childe's (1946) renowned conception of iron as a 'democratic metal', a cheap and widespread metal 'obtainable by people independent of kings and chieftains' does not concur with the facts on the ground. Apparently, chieftains and kings and socio-economic decisions beyond the individual were needed in order to turn iron into a commonly used metal.

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